United States Department of Agriculture

Office of the Chief Information Officer
Network Engineering Division

Telecommunications Enterprise Network Design

Comprehensive Network Baseline Analysis
Task III Report

January 6, 1998
Revised June 9, 1998

Executive Summary

The USDA Telecommunications Stabilization and Migration Program establishes the overall plan for the creation of the USDA Telecommunications Enterprise Network. The Information Systems Telecommunications Architecture establishes the Telecommunications Enterprise Network requirements, while implementation of Telecommunications Enterprise Network design requirements is described in the Geographic Network Analysis Process.

Using the Geographic Network Analysis Process, the Network Engineering Division has developed a detailed description of the current USDA Data Networks. The parameters of this Comprehensive Network Baseline Analysis are network equipment, service, utilization, performance, cost , and survivability. The NetMaker XA® System, used to construct the Baseline, electronically discovers the nature of the network hardware elements, measures network usage and performance, calculates appropriate costs, and simulates failure modes to determine survivability.

Key Concepts

- USDA Network router software is out-of-date. Only 13% of the USDA routers use software that is fully supported by the Vendor.
- USDA Data Networks are underutilized. On an "average" day nearly 80% of the circuits are used at less than 10% of theoretical capacity.
- The Baseline Study reveals that most Agency services are independently contracted. Development of the Initial Enterprise Network will consolidate network services contracting and thus gain benefits from economy of scale. Benefits of pooled resources include reduced cost, better performance, and better reliability.
- The Network Cost Metric for the existing USDA Data Networks is $1.26M per month. Eighty percent of the total is recurring Monthly Cost of Services
- Most USDA Data Network topologies are Agency specific, with network configurations converging on central locations. This configuration does not effectively support shared agency connections. City-to-city consolidation, without re-engineering of WAN networks, causes problems in network capacity, performance, and reliability.

Equipment

The Comprehensive Baseline Analysis shows that only a very small percentage (18%) of the current USDA router software base is fully supported by the vendor(s). Software with absolutely no vendor support is 41%. The remaining software in use is at various stages of extinction due to 'aging' (Fig. A). This may present upward compatibility problems when routers using different software try to communicate. The use of unsupported software exposes USDA Agencies to potentially expensive network downtime when equipment failure occurs. In addition, Agencies are not able to take advantage of the latest router features (e.g. new security features).

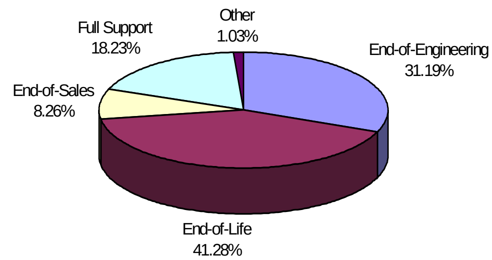


Figure A Support Status of USDA Networks Router Software

Network Services

Many network services are required by USDA Agencies to complete their mission programs. These services include access to the Internet, USDA Data Centers, and Dial-Up needs. The Baseline Study reveals that most Agency services are independently contracted. Development of the Initial Enterprise Network will consolidate network services contracting and thus gain the benefits from economy of scale. Benefits of pooled resources include reduced cost, better performance, and better reliability.

Network Utilization

Network utilization is defined as the amount of data traffic on network interconnections. Based on the identification of 693 network connections, an “average” and “high” day utilization has been calculated. The data indicates that on an “average’ day 79% and on a “high” day 64% of USDA telecommunications network circuits are used at less than 10% of their theoretical capacity. The very inefficient use of USDA Network circuits is a prime area for significant improvement and cost savings.

Network Performance

Performance assessment of the USDA Data Networks requires a sufficient amount (e.g. a month’s worth) of traffic data to create ‘real’ application traffic models. In the overall Initial Enterprise Network Design Plan, the Application Level Traffic Study is scheduled for completion in the first half of March 1998. This date has recently been extended to the middle of March to allow more complete data collection of Application Level Traffic.

Network Cost

The Network Baseline Study has defined a Network Cost Metric to permit evaluation of new network designs compared to existing USDA network cost. The Network Cost Metric is the sum of recurring monthly service costs, recurring monthly equipment maintenance costs, and amortized capital equipment costs (Fig. B). For the existing USDA Data Networks, recurring monthly service cost is $1.01M, recurring monthly equipment maintenance cost is $57,000, and amortized capital equipment cost is $190,000. The resulting monthly USDA Network Cost Metric for the Network Baseline is $1.26M.

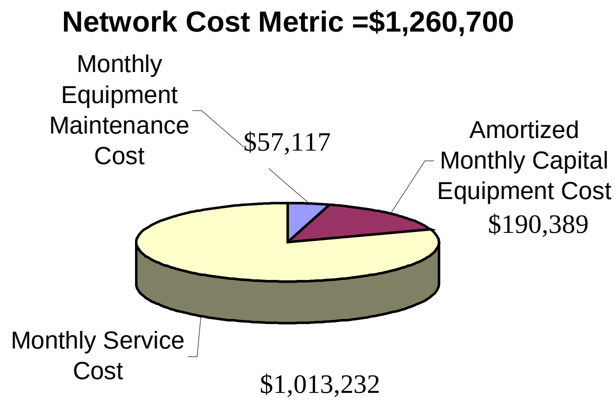


Figure B Network Cost Metric

Network Topology

Most USDA Agency Data Networks, independently designed and constructed, are configured as variations of a star topology. The star network topology limits direct connectivity between Agencies and increases the probability of network failure when networks are shared by multiple Agencies. Figure C shows independent networks converging to central locations. A converging network topology does not effectively support multiple agency connections. In addition, a converging network topology is vulnerable to reduced performance from circuit overloading and wide-scale system down-time due to single network element failures. Building-by-building or city-by-city consolidations alone, without re-engineering of higher level network connections, cause problems in network capacity, performance and reliability. Application of the Geographic Network Analysis Process for the high level or WAN networks while accounting for LAN to LAN traffic flows will resolve these problems.

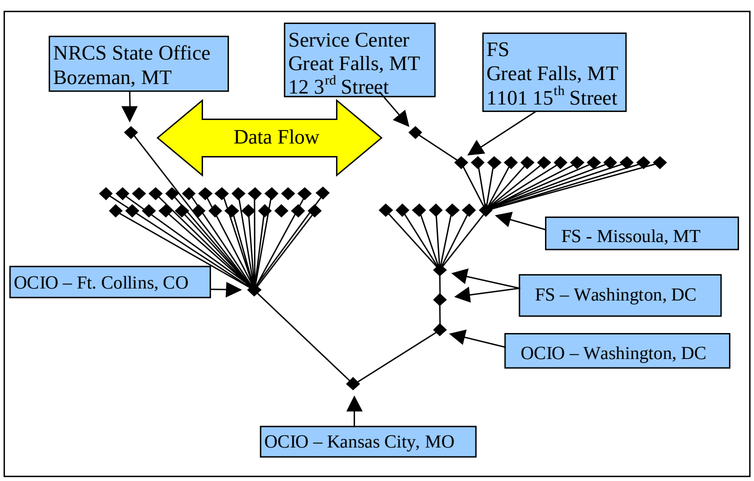


Figure C Independent Networks Connected to a Central Hub

Network Survivability

Failure analysis examines the effects of failed network components, such as network nodes and links, on traffic being exchanged within the network at the time of the failure. Network survivability assessment of USDA Networks is simulated using the Network Baseline Model and 'real' application level traffic models. The traffic models, currently being compiled, will be available in the middle of March 1998.

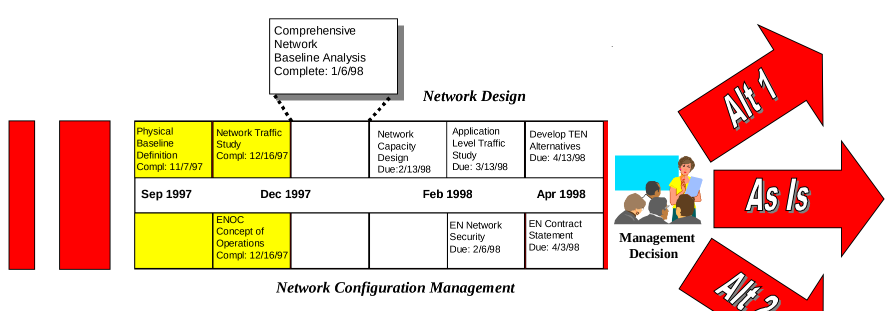
Geographic Network Analysis Process

The USDA Geographic Network Analysis Process is being used throughout the development of the Initial Enterprise Network. To date effort has focused on the Process' Data Collection phase acquiring USDA Data Network physical topology information and network level traffic data. The design effort is now at the conclusion of the Baseline Modeling phase where a comprehensive model of the current USDA Data Networks has been created. The Geographic Network Analysis Process, which has worked well in the initial two phases of network design, insures objectivity and uniformity of analysis and implementation of telecommunications data networks throughout the USDA. No modification of the Geographic Network Analysis Process is anticipated.

What's Next?

The goal of the Initial Enterprise Network Design project is to provide USDA management with sufficient information to understand the current USDA Data Network and recommendations upon which to determine the continued development of the Enterprise Network. The **EN Development Task Flow** chart graphically depicts the Initial Enterprise Network Design Project status.

The Network Architecture and Design Team continues to define the current network with the Application Level Study and begins Initial Enterprise Network design with the Network Capacity Design task. The Application Level Traffic Study examines the USDA Data Networks to determine the applications in use by USDA Agencies. The Network Capacity Design task develops recommendations, based on Baseline analysis, for current USDA Data Networks capacity requirements that maintain performance standards. Finally, management will be provided with Initial Enterprise Network design alternatives which allow the integration of Agency networks into a shared network utility.



EN Development Task Flow

1.0 Introduction

1.1 Objectives

In compliance with the Geographic Network Analysis Process (GNAP), the Office of the Chief Information Officer, Telecommunications Services and Operations, Network Engineering Division initiated activities necessary to define the existing USDA Data Networks. There are two objectives for these activities. The first is a comprehensive **description** of the existing USDA Data Networks in terms of equipment (type, numbers, features)[1] and Network Level Traffic[2] which addresses the amount and type of traffic relative to specific agencies. The second objective is an **analysis** of the information derived from the Physical Baseline Description and the Network Level Traffic Study. The Comprehensive Network Baseline Report provides conclusions regarding the existing status of network parameters – equipment, services, utilization, cost, performance and survivability.

1.2 Background

The mission programs of the USDA Agencies are a diverse set of agriculture, forestry, rural development, aquaculture, human nutrition, and research programs that require substantial telecommunications resources which include, but are not limited to, local and long distance telephone service, interactive access to remote computers, electronic mail and electronic commerce, file transfer between remote workstations, Internet and external network access, and teleconferencing, both audio and video. Success of Agency mission programs is measured in terms of information availability - the right time, the right place, and the right customer. The solution is a systematically engineered Telecommunications Enterprise Network (TEN), conceptualized in Fig. 1, based on USDA business requirements, customer service, and cost efficiency.

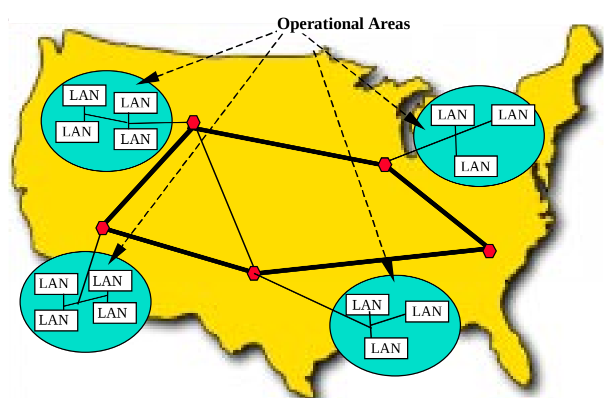


Figure 1 Enterprise Network Conceptual Design

[1] Telecommunications Enterprise Network Design, Physical Baseline Definition of USDA Data Networks – Task I Report. November 7, 1997. Network Engineering Division.
[2] Telecommunications Enterprise Network Design, Network Level Traffic Study of USDA Data Networks – Task II Report. December 16. 1997. Network Engineering Division

1.2.1 Information Systems Technology Architecture

The USDA Information Systems Technology Architecture (ISTA) represents a coherent plan facilitating informed decision-making regarding technology and services needed to support business objectives. The ISTA relies on institutional processes and policies to identify, describe, and validate the business objectives of the USDA (Fig. 2). The ISTA consists of three parts that address information technology infrastructure, descriptive information about USDA information environment, and information technology standards.

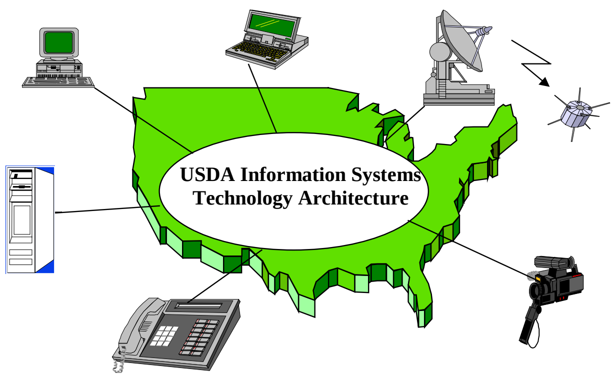


Figure 2 USDA Information Systems Technology Architecture

ISTA Part I – Business/Data Architecture, documents core processes and information necessary for USDA to conduct business. This architecture component merges data elements and business processes into a single strategy for establishing current and long-term requirements. Program and management requirements are described in terms of business processes, which can be compared and analyzed for opportunities to consolidate and improve efficiency.

ISTA Part II – Technical Architecture, describes technology and standards needed to meet the requirements of the Business Architecture. This part of the ISTA reflects the recognition that technical standards and new technology must be evaluated prior to Information Technology (IT) systems development and modification.

ISTA Part III – Telecommunications Architecture, describes how USDA develops and maintains telecommunications services. The intent of the Telecommunications Architecture is to establish and sustain an information telecommunications environment optimized for meeting Agency mission programs while maintaining cost efficiency.

1.2.2 Telecommunications Network Stabilization and Migration Program

The Telecommunications Network Stabilization and Migration Program (TNSMP), released in April 1997, establishes a plan, in relation to the justification, program requirements, and strategic objectives, for the development of a USDA Telecommunications Enterprise Network. The TNSMP is divided into two operational phases. Phase I is designed to stabilize the current telecommunications environment while providing processes and procedures to enable planning, acquisition, and management of USDA Telecommunications assets. Phase II of the TNSMP addresses the details and processes for USDA migration to a cost effective, coordinated and documented USDA Telecommunications Enterprise Network serving all Agencies. Implementation of this phase of the TNSMP is described in the TNSMP Plan. An overview of the TNSMP is presented in Figure 3. Another significant mandate of the TNSMP is the development and implementation of a network design process which produces a design for USDA network satisfying the connectivity needs of USDA systems, processes and users in the most cost effective manner.

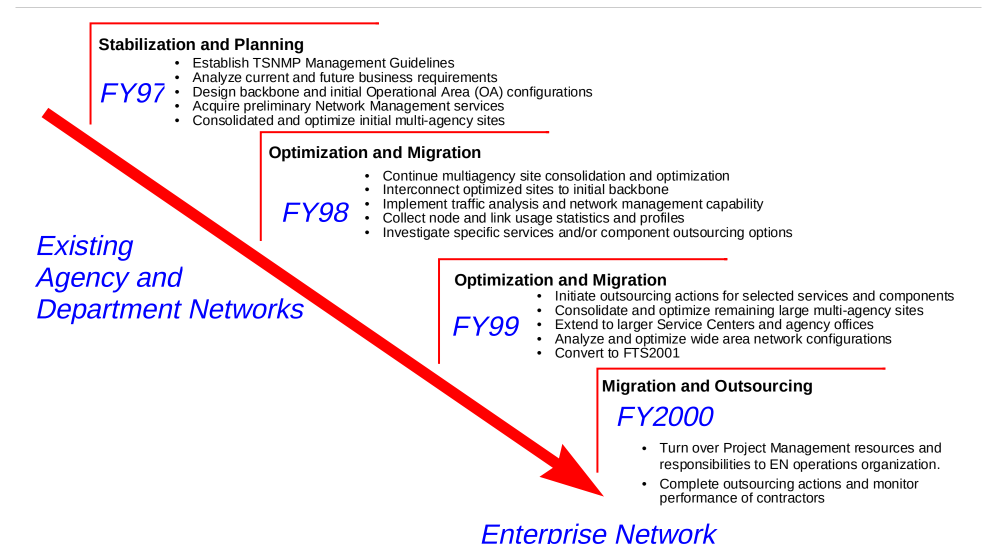


Figure 3 Telecommunications Network Stabilization and Migration Program

1.2.3 TNSMP Plan

The October 1, 1997 TNSMP Plan (Program Plan) describes the approach that the OCIO is taking to implement the TNSMP. The Program Plan approach is logical and cost effective. It provides near-term resolution of current operating issues and immediate cost savings while creating a straight-forward path to the USDA TEN. The Program Plan proposes six initiatives which, upon completion, result in a fully operational IEN. All six initiatives are defined in detail in the TNSMP Plan.

1.2.4 Geographic Network Analysis Process

A common thread linking all aspects of the USDA Telecommunications Planning Processes is standardization. Standardization promotes cost efficiency by optimizing the selection and procurement of telecommunications services and equipment. The USDA recognizes the need for a network design process applied uniformly throughout the Department while also being sensitive to Agency specific missions. The

USDA Geographic Network Analysis Process (GNAP) is technically sound, flexible and adaptable to emerging technologies and their inherent economics.

The USDA GNAP (Fig. 4) is divided into four parts:

- Data Collection
- Modeling
- Optimization
- Design Alternatives

The modeling phase of the design process results in a description of physical elements and a description of dynamic aspects of the existing USDA Data Networks. This Comprehensive Network Baseline is a necessary prerequisite to the development of a new network design. The Network Baseline provides a reference to which all new designs and proposed changes are evaluated.

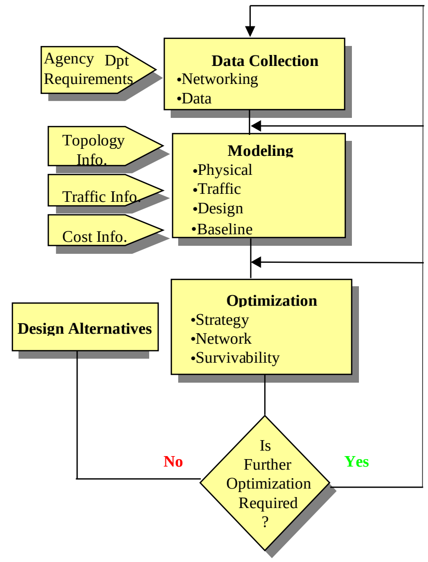


Figure 4 GNAP Flowchart

1.3 Telecommunications Network Baseline

1.3.1 Definition

The Network Baseline, part of the Design Process modeling phase, is a description of the initial state of a network in terms of the level of service delivered to the end-user. Accessibility, reliability, and capacity are the network parameters that define the level of service. These descriptions, in turn, are given by network equipment, applications and features, traffic, cost, and robustness.

1.3.2 Describing the Network Baseline

Physical Baseline information refers to the physical elements of the network –routers, Local Area Networks (LANs), frame relay Points-of-Presence (POP), and transmission connections such as Wide Area Network (WAN) links, and links to LANs and Frame Relay links. The data for the baseline description is derived from two sources, data calls and electronic discovery.

Data calls are information derived from Agency feedback to directed queries. In the Comprehensive Baseline Analysis report, two mechanisms were used to get information. At the beginning of the baseline definition task, a memorandum addressed to each Agency telecommunications representative opportunity for Agency feedback was provided as part of the initial report of the Physical Baseline study. Information known about each agency was provided to the agency representative, and the representative was asked to both verify the information and provide specific missing data.

Electronic discovery involves use of the NetMaker XA® [3]System to obtain the information stored inside each network. The information derived depends on how the node is configured but may include name, location, link speeds, and connectivity. Automatic determination of connectivity permits the mapping of entire networks based on Management Information Base(MIB) data.

1.3.3 Significance of Network Baseline Description

The description of a network baseline is fundamental to good network engineering practices. The network baseline description, by thoroughly describing the hardware, software, and characteristics of the network, represents the standards to which network development is referenced. The highest level goal of the TNSMP is to develop a USDA network with equal or better performance at reduced cost. The network baseline provides the reference for insuring the operation of the Enterprise Network at a level meeting or exceeding each agency's mission requirements. Following its initial determination, the Network Baseline is updated routinely as new information is derived or made available. This dynamic baseline model insures that there is significant value to proposed network changes and additions.

1.3.4 Network Baseline Parameters

The description of the USDA Telecommunications Network Baseline requires knowledge of six parameters.

- Equipment
- Service
- Utilization
- Performance
- Cost
- Survivability

[3] NetMaker XA® is a registered trademark of Make Systems, Inc.

Collectively these parameters define the physical elements as well as dynamic aspects of the network. The remainder of this report is the measurement and analysis of these parameters.

2.0 Methodology

2.1 Baseline Modeling Methodology

The USDA Data Networks Comprehensive Baseline Analysis (modeling of the baseline) uses four distinct processes to determine the networks' attributes. The complexity and the large size of the combined USDA Data Networks require that the process rely heavily on the modeling capabilities of NetMaker XA®. The four processes are:

- Definition of the Physical Topology of the Networks
- Network Level Traffic Analysis
- Cost Evaluation of the Networks
- Networks' Survivability Analysis

The NetMaker XA® system includes a set of tools and databases which help the acquisition of data used in the analysis presented in this report.

2.2 Physical Topology of the Networks

The topology of the existing USDA Data Networks is determined by using the industry standard NetMaker XA® Simple Network Management Protocol (SNMP) agent to dynamically poll the standard SNMP compliant USDA network nodes. The information retrieved from this process includes attributes for network routers and their associated interfaces (both WAN and LAN). Using this information and additional data obtained from the Agencies, a model of the physical topology of the networks is created; including geographical views and detailed reports on the network nodes and links. The model is stored in NetMaker XA® for further modeling. A detailed description of the Physical Baseline is the subject of a separate report — *Telecommunications Enterprise Network Design, Physical Baseline Definition of USDA Data Networks - Task I Report. November 7, 1997. Network Engineering Division.*

2.3 Network Level Traffic information

The Baseline WAN plug-in for the NetMaker XA® Interpreter tool supports the collection of network node MIB statistics using the same protocol (SNMP) as in the networks topology discovery procedure described above. The procedure collects, for a pre-defined period, router statistics on the amount of traffic at each of the device's serial interfaces. As a result, the tool generates a set of reports which indicate trends in usage over time. The trends are used to pinpoint the busiest links, and periods of the day. Once the network link traffic information is collected, the reports are converted to individual 'demands' that are mapped onto the USDA Data Networks physical model. The result of this process is a detailed network level traffic baseline; the subject of a separate report — *Telecommunications Enterprise Network Design, Network Level Traffic Study of USDA Networks – Task II. December 16, 1997. Network Engineering Division.*

2.4 Network Performance

In the context of the USDA Data Networks Baseline Analysis, performance is measured in terms of network link delays. Two "delay" types are considered:

- Queuing delay – The queuing delay for a demand (an instance of traffic) which is fed through a given queue along with other demands, may be calculated given the arrival demand characteristics, including arrival rate and mean packet size and the mean service rate.
- Link Delay - The overall delay (T_d) of a link is composed of the queuing delay (Q_d), the transmission time (T_t), and the propagation delay (P_d).
  $(\mathbf{T_d = Q_d + T_t + P_d})$

The attributes accurately defining delay characteristics are determined by analyzing actual Application Level Traffic. The Application Level Traffic is derived as a set of traffic demands (defined on a protocol basis) derived from the actual network traffic captured with network probes – Sniffers. Once the demands are 'imported', the NetMaker XA® tool uses industry recognized algorithms to generate queuing models and calculate the various delay parameters associated with demands and links (e.g. forward and return delay – average/maximum, round trip delay – average/maximum, and packet delay – average/maximum).

2.5 Network Cost Information

The Accountant tool within NetMaker XA® is the financial modeling tool for tracking and allocating network costs. The Accountant tool generates cost information on the existing network. In addition, the Accountant tool can be used during the network design and optimization phases by determining the least-cost providers of bandwidth or allocating bandwidth and equipment cost among network users. For the purpose of the USDA Data Networks Baseline Analysis, only functions related to costing the existing networks are used. NetMaker XA® contains an integral set of tariff databases such as Local Exchange Carriers (LECs), Inter-LATA Exchange Carriers (IXCs) and Federal (i.e. FTS2000). It also provides the capability to customize all tariff databases. The three functions used by the Accountant to provide cost information are: a) auto-location of objects within the topological display, b) the distance computation of links, and c) the link pricing. The network cost reports generated by NetMaker XA® for the USDA Data Networks become an integral part of the Baseline Model.

2.6 Survivability Analysis

Network survivability refers to the robustness of network design. A network design that can maintain normal operation at times of network element failure is said to be survivable. NetMaker XA® can simulate single or multiple event network failures. The result of the simulation exercise is a set of reports establishing worst case failures and Network Survivability Indices. In addition, the Survivability Analysis Log identifies locations and particular traffic demand(s) affected by the failure(s).

3.0 Results

3.1 Network Equipment

The data presented in this section was obtained from the “discovery” of the USDA Data Networks performed as of January 30, 1998. The discovery process polls all accessible devices supporting the SNMP. As a result, devices such as routers, servers, and even personal computers were discovered within the USDA networks. However, network devices discovered were predominantly Cisco routers with a very small number of Welfleet and 3Com routers.

3.1.1 Routers

The central piece of network equipment in most USDA WANs is the router. It is the device used to bring physical connectivity between LANs and WAN data circuits. It also provides the logical intelligence to route traffic from source to destination locations. Due to the router’s importance in Wide Area Networking, it is the focus of the Network Equipment Baseline analysis.

Figure 5 shows the distribution, by manufacturer, of 921 routers discovered in the USDA network. Cisco, with 94.7%, is by far the predominant router platform in the network. Because the next closest manufacturer has less than one percent of the router population, only Cisco routers are analyzed in this report. The bulk of the “other” category is LAN servers performing router functions.

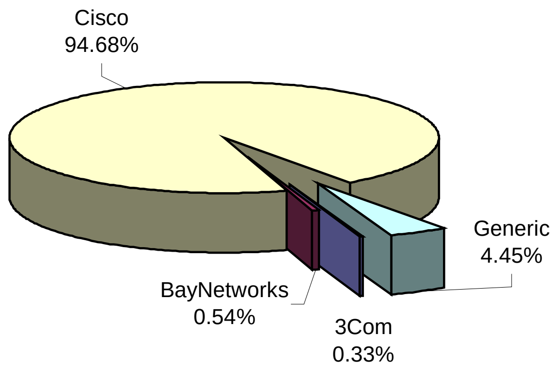


Figure 5 Types of Routers Discovered in USDA Data Networks

The breakdown of the Cisco router inventory by chassis type is presented in Figure 6. General descriptions of each type are as follows:

- 7000 – High-end core router series – Provides reliability, availability, serviceability, and performance features. Used to meet the requirements of most mission-critical internetworks, usually at the backbone level. This series is modular, providing interchangeable and redundant components.
- 4000 – High density mid-level router series – Provides LAN and WAN access in a mid-cost modular router platform. Meets the needs of most large end node and mid-level network locations. This series is modular, providing interchangeable components.
- 3000 – Older Mid-level router series – Provides LAN and WAN access in a low-cost router platform.
- 2500 – Mid-level end router series – Provides LAN and WAN access in a low-cost router platform. Meets the needs of most end node network locations.
- Other – Other Cisco routers include End-of-life routers such as the AGS and IGS chassis, and other router platforms such as the 3600 communications server.

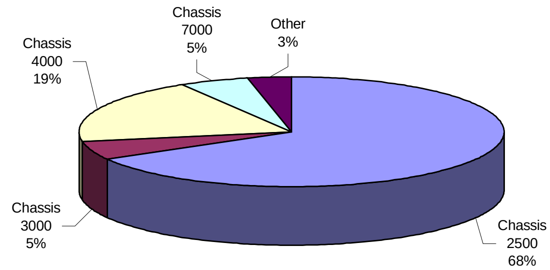


Figure 6 Cisco Router Chassis Discovered on USDA Data Networks

Each of these chassis types is characterized by several models. Within each of these categories, the various model types are at different levels of support. For example, within the 7000 chassis type there are model series 7000, 7200, and 7500. Detailed information on specific model series types for the USDA Data Networks is not available from the automated SNMP polling process. Because of this, a detailed analysis of the chassis type inventory is not possible. However, based on the small number of unsupported routers within the categories discovered, most router hardware platforms in the Department continue to be supported. The following table shows which specific Cisco models within the known USDA base of chassis types have reached or are close to their end-of-support date.

Cisco Model	Description	End-of-Support Date
IGS	Integrated Gateway Server	1996
AGS+/3	AGS+ 68020 4-MB, 9 Slot Multiprotocol Router	November 30, 1997
AGS+/4	AGS+ 68040 16-MB, 9 Slot Multiprotocol Router	December 1, 1998
CISCO4500	4500 Modular Multiprotocol Router, AC Power	May 17, 1998

Table 1 Hardware Support

Figure 7 shows geographically by LATA where high concentrations of routers in the USDA Data Network are located. The same information is shown numerically in Table 2. The LATA boundary is chosen because of the cost advantages of concentrating data traffic within a LATA before it is transmitted between LATAs. All LATAs containing more than ten routers are indicated on the map; providing some indication of where the existing USDA Data Networks are concentrated.

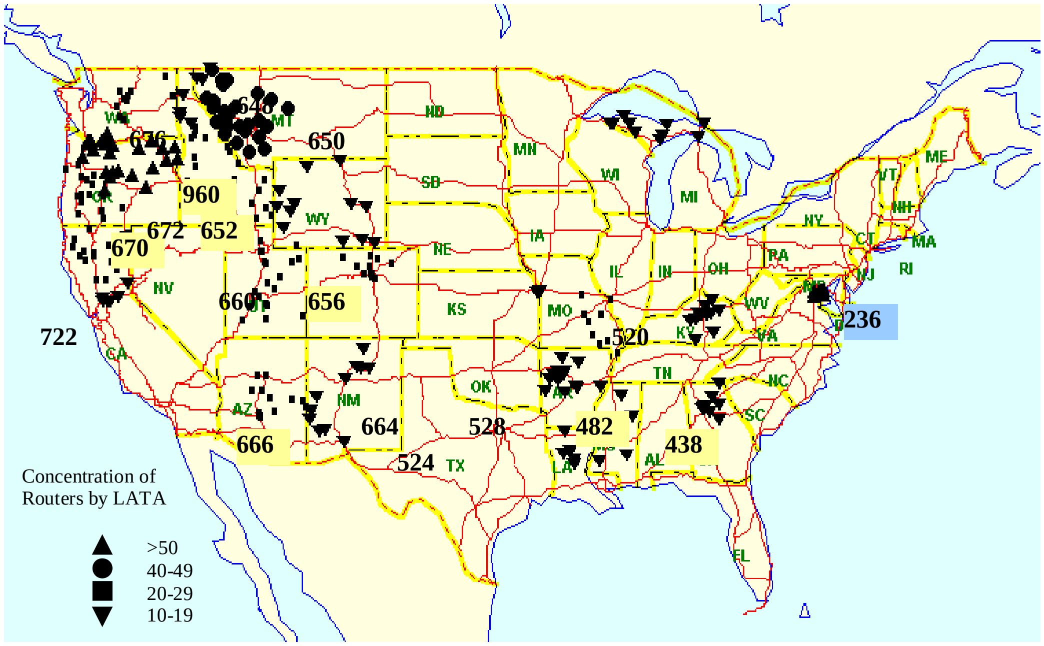


Figure 7 Router Distribution by LATA

LATA Number	Number of Routers	LATA Location
236	63	Washington, D.C.
342	10	Upper Peninsula, MI
438	16	Atlanta, GA
466	12	Winchester, KY
482	16	Jackson, MS
486	16	Shreveport, LA
520	20	St. Louis, MO
524	11	Midland, TX
528	14	Little Rock, AR
648	44	Grand Falls, MT
652	28	Idaho
654	17	Wyoming
656	28	Denver, CO
660	26	Utah
664	16	New Mexico
666	28	Phoenix, AZ
670	25	Eugene, OR
672	50	Portland, OR
676	21	Spokane, WA
724	24	Chico, CA
726	10	Sacramento, CA
960	11	Coeur D'Alene, ID

Table 2 Numbers of Routers in Selected LATAs

3.1.2 Software Support

The Inter-network Operating System (IOS) characterizes the software for all Cisco routers. The IOS is updated regularly by Cisco using a well-defined process consisting of major software releases and, when necessary, maintenance releases within a major release. Figure 8 shows the level of support, as of December 1997, for the IOS implementations within the USDA Data Networks. For clarity, only the major release status is presented. The level of support of the IOS are classified into four categories:

- **End-of-Life (EOL) -** The software release is no longer supported by Cisco's
  Customer Service Engineering (CSE) and is removed from Cisco Connection Online (CCO). This category includes Releases 8.3 to 10.2
- **End-of Engineering (EOE) -** The EOE status indicates that no scheduled maintenance will be produced for the major release. The release is still available through Field Service Office (FSO) and CCO for customers under maintenance contract or for CSE support until it reaches the EOL status. Release 10.3 is the only software version in this category.
- **End-of Sales (EOS)** - The software release may no longer be ordered. Releases with EOS status are still available through FSO and CCO for customers under maintenance contracts or for CSE support until it reaches the EOL status. Release 11.0 is the EOS version software release.
- **Full Support (FS)** - The software release is sold and is fully supported. *IOS* Releases 11.1 and 11.2 are currently fully supported by Cisco.

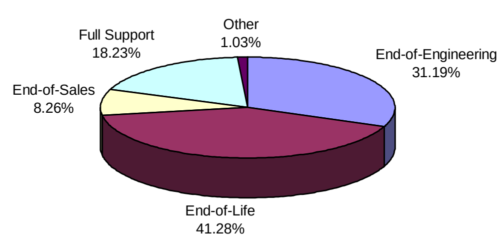


Figure 8 Cisco Router Software Support

Bay Networks, Inc. absorbed Welfleet in 1994, discontinuing the support on all Welfleet Routers except for the highest capacity models. High capacity models were subsequently phased out in 1996. For those few 'top' routers, hardware and firmware updates were implemented to make them 'Bay Networks' routers. Since USDA Welfleet routers appear to the discovery as

Welfleet, we assume that Bay Networks, Inc. no longer supports these devices. At the time of this report, no specific status information was available for the USDA's 3Com devices.

3.1.3 WAN Links

WAN links, in addition to routers, are fundamental building blocks for USDA Data Networks. WAN links are used to interconnect geographically distant LANs. WAN links are made using many different technologies such as X.25, Dedicated Transmission Service (DTS), Frame Relay, and Asynchronous or Synchronous Dial-up. Regardless of link technology, WAN links all connect two physical network locations. In addition to the differences in network technology, the links also differ in type and speed. Table 3 shows the distribution of the current inventory of USDA Networks links by type or speed.

Number of WAN Links by type or speed	
0-64K	225
65-128K	61
129-256K	52
385-512K	17
513-768K	35
769-1024K	4
1025-1536K	49
T1	258
E1	1
Total	**702**

Table 3 WAN Links

Figure 9 shows geographically by LATA where there are high concentrations of WAN Links (both DTS end points and Frame Relay access) in the USDA Data Networks. The same information is presented numerically in Table 4. The LATA boundary is chosen because of the cost advantages of concentrating data traffic within a LATA before it is transmitted between LATAs. The map shows all LATAs containing more than ten WAN link termination points and USDA Data Network physical locations.

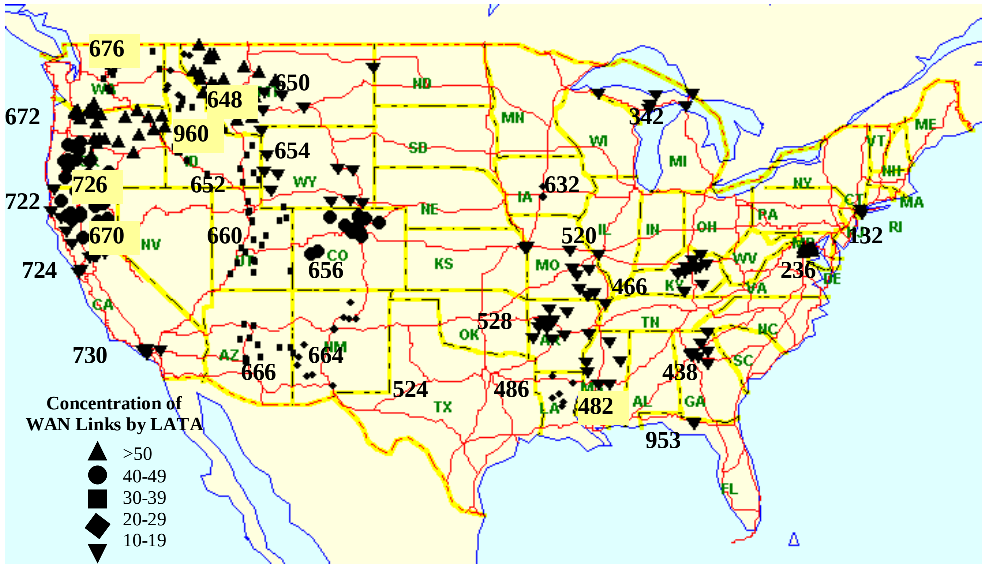


Figure 9 WAN Links Distribution by LATA

LATA Number	Number of WAN Links	LATA Location
132	12	New York Metro
236	49	Washington, D.C.
256	13	Clarksburg, West Virginia
342	11	Upper Peninsula, MI
438	15	Atlanta, GA
466	10	Winchester, KY
482	25	Jackson, Mississippi
520	16	St. Louis, Missouri
524	19	Midland, Texas
552	16	Dallas, Texas
632	16	Des Moines, Iowa
648	56	Grand Falls, Montana

LATA Number	Number of WAN Links	LATA Location
652	38	Idaho
656	42	Denver, Colorado
660	57	Utah
664	13	New Mexico
666	29	Phoenix, Arizona
670	57	Eugene, Oregon
672	68	Portland, Oregon
676	42	Spokane, Washington
722	22	San Francisco, California
724	20	Chico, California
726	17	Sacramento, California
960	25	Coeur D'Alene, Idaho

Table 4 Number of WAN Links in Selected LATAs

3.2 Network Services

USDA Data Networks interconnect sub-networks, external services and other organizations as required by the very diversified business needs and missions of

USDA Agencies. The Network Baseline Study has identified nine primary interconnections found on USDA Data Networks.

3.2.1 Local Area Networks (LANs)

Interconnection of LANs is of the most 'popular' service used by the USDA Networks. LAN networks are collections of independent workstations, servers and concentrator nodes that communicate with one another over a shared network medium. LANs are usually confined to a building or campus. Several LAN types are implemented with the USDA networks. (Figure 10)

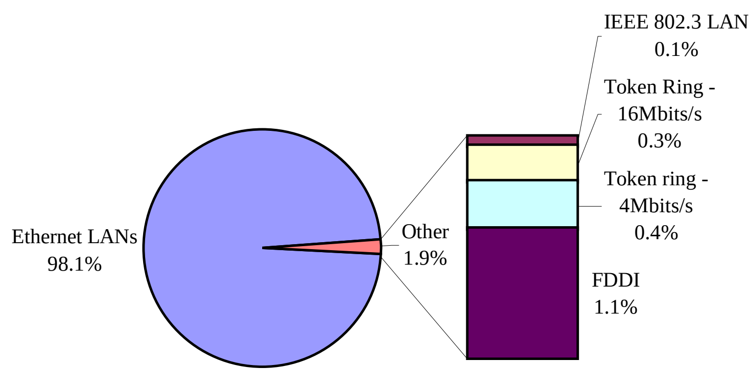


Figure 10 Types of LANs on USDA Data Networks

3.2.1.1 Ethernet LAN

The Ethernet LAN is, by far, the most prevalent LAN technology being used by USDA Agencies. The Ethernet Protocol specifies how data is placed on and retrieved from a common transmission medium. It uses a technique called 'carrier sense multiple access / collision detection' (CSMA/CD) to enable any device on the LAN to access the medium at any time. The current implementations of Ethernet support transfer rate of 10 and 100 Mbit/s. It supports virtually all popular network protocols, including Transmission Control Protocol/Internet Protocol (TCP/IP). Ethernet is recognized as a reasonable compromise between speed, cost and ease of installation.

3.2.1.2 IEEE 802.3 LAN

One IEEE 802.3 LAN was found by NetMaker XA® during the December 1, 1997 discovery. Differences between Ethernet and

IEEE 802.3 LAN are subtle. While Ethernet (also based on IEEE 802.3 Standard) provides services corresponding to Layer 1 and 2 of the Open System Interconnections (OSI) model, IEEE 802.3 specifies the Physical Layer (Layer 1) and the channel-access portion of the Link Layer (Layer 2). Therefore, it does not define a logical link control protocol as Ethernet does.

3.2.1.3 Token Ring LAN

A few Token Ring LANs are implemented among the USDA Agencies' networks. The Token Ring LAN is a physical star-wired architecture which, by definition, is a deterministic topology, that is, the sequence by which users gain access to the LAN is predetermined. A controlling station on the LAN generates a special signaling sequence called a "token" that controls the right to transmit. The Token Ring LAN is recognized as allowing all nodes on the LAN to share the network bandwidth in an orderly and efficient manner. USDA Token Ring implementations support transfer rates of 4 and 16 Mbit/s.

3.2.1.4 Fiber Distributed Data Interface (FDDI) LAN

Several FDDI LANs are implemented within the USDA Data Networks. There is a concentration of five USDA fiber rings in the Washington DC, Metropolitan Area. FDDI is a 100 Mbit/s LAN defined by the American National Standards Institute (ANSI) and OSI standards. While it was originally designed to operate over fiber optic cabling, FDDI now also includes standard copper media. FDDI is commonly used as a backbone technology to interconnect smaller LANs (e.g. Ethernet). FDDI uses a token media access control protocol - Timed Token. FDDI uses three basic topologies: Ring, Star and Tree. These topologies can be combined to build large networks (up to 500 nodes). FDDI is used whenever high reliability and/or high transfer rate are required.

3.2.2 Internet Access

All agencies responding to the survey reported use of the Internet. Most Agencies rely on the USDA Internet Service Provider (ISP), although some have a separate primary ISP, and others report that their field offices have established arrangements with local ISPs.

3.2.3 USDA Data Centers

All agencies within USDA connect to one or both of the Department's main IBM data centers. These centers are the National Finance Center in New Orleans, LA, and the National Information Technology Center in Kansas City, MO. These two data centers support a wide variety of administrative and Agency Program Area applications.

3.2.4 Web Servers

Web Servers are used by most agencies to provide information to the public and field staff. Many Agencies have established a principal web server at their main headquarters location; however some report that they have servers in most or all their important field sites. Where Agencies report not having web servers, they indicated that they are using the USDA web server.

3.2.5 Dial-up Access Needs

Dial-up needs within USDA Agencies range from support for Flexiplace and traveling employees to connection with outside services or provisions for clients to submit data. In Agencies where network access has not penetrated to all field offices, dial-up access is used in field offices as well. In general, this dial-up access is handled through NITC.

There are some Agencies reporting modems in use in the headquarters area, even though network access is readily available. These modems are used either to connect outside information services or to allow users to dial in to networks that do not presently support the remote access capabilities available through Kansas City. In these instances software such as PC-Anywhere, Carbon Copy, or Laplink Remote is used.

3.2.6 FTS Mail

Some Agencies are still relying on FTS Mail, especially where networks have not fully penetrated to the field. Even these organizations expect to change to another mail system in the next 12-18 months.

3.2.7 Other Government Agencies

USDA Agencies connect to several other departments and agencies in the Federal Government. Connections include the Department of Commerce (including Bureau of Census and National Weather Service), Department of Treasury (including Customs), Health and Human Services (and Social Security Administration), Federal Reserve Board, Department of Labor, Department of Interior (including Bureau of Land Management), State

Department, and Housing and Urban Development. These connections may be at headquarters complexes, or at field offices.

3.2.8 State and Local Entities

Several Agencies share information, or access data from, state and local agencies including colleges and universities, state Departments of State (for lien and title information), and Treasury Departments (for bankruptcy and appraisal information). These connections may be dial-up, X.25 packet-switched, leases-line, router gateway, or through the Internet.

3.2.9 Commercial Organizations

Some USDA Agencies interact with commercial organizations as part of their mission programs. Agencies report connections to trade groups, banks and financial institutions, credit-reporting institutions, new services (including weather and financial reports), client-customer organizations (these include rental agents and cooperative services for Rural Development), outside computing service providers (IBM, Lockheed-Martin, etc.) and contractors (FIServ, EDS, AMS and others).

3.3 Network Utilization

The data presented in this section summarizes the amount of data traffic on the existing USDA network interconnections. Measurement of network data traffic uses the method of electronically polling network components and retrieving usage data for each interconnection. In addition, line speed information is electronically collected from router configurations. The network utilization analysis is dependant on the accuracy of the line speed information. As additional usage data is collected for the circuits and line speed information is corrected in router configurations, the accuracy of the network level traffic analysis will improve.

The electronically retrieved data is imported into a database and processed. Based on the number of circuits identified in the November 7, 1997 Physical Baseline Report, data has been collected for 702 interconnections. The January 30, 1998 discovery identified 921 interconnections. Data will be collected on the additional circuits as the design process proceeds. The analysis presented in this section does not include the circuits for which no data was collected; and therefore, is not artificially skewed.

Once the raw usage data is collected, profiles for high and average usage are created for each WAN Link per sampled time slice. This data is then imported by the NetMaker XA® Modeling tool and analyzed using the network model derived from the automated discovery process. The resulting usage analysis is presented in

Figures 11 and 12 for the "average" and "high" usage data respectively.[4] The figures show the percentage of USDA Network links that fall within the specified Network utilization ranges. These utilization ranges are expressed as total link capacity in 10% increments.

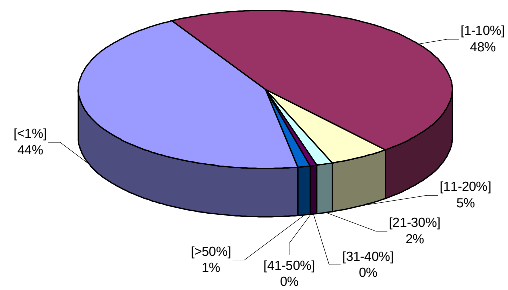


Figure 11 "Average" Day Utilization

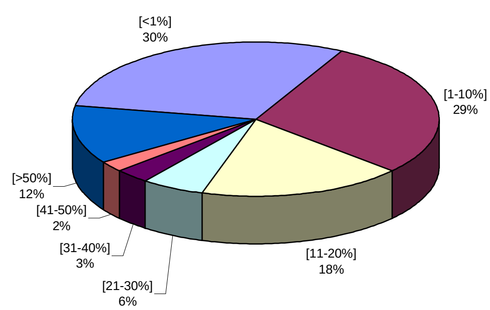


Figure 12 "High" Day Utilization

The data for this report, collected in November and early December, reflects historically low utilization months for the USDA. The analysis of network capacity takes this information into consideration when identifying those circuits are candidates for change. Additional usage data will be collected in early January. Figure 13 shows historical usage (a value of 1 is average utilization) for voice and X.25 over fiscal year 1997. Although this data is not representative of the types of circuits sampled for the data circuit utilization presented in this report, it does provide some insight into past network usage trends.

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[4] Samples were collected from 6 A.M. EST to 6 P.M. PST on weekdays, on thirteen days between November 4, 1997 and December 5, 1997. Holidays and the Friday after Thanksgiving were excluded. The data collected is organized into 15, one hour samples for each day. For each time slice, the samples collected represent the number of bytes and the number of packets transferred in and out for each link. The "Average" Day is calculated as the average of each one-hour time slice for all of the sampled days. The "High" Day is calculated as the high value of each one-hour time slice for all of the sampled days.

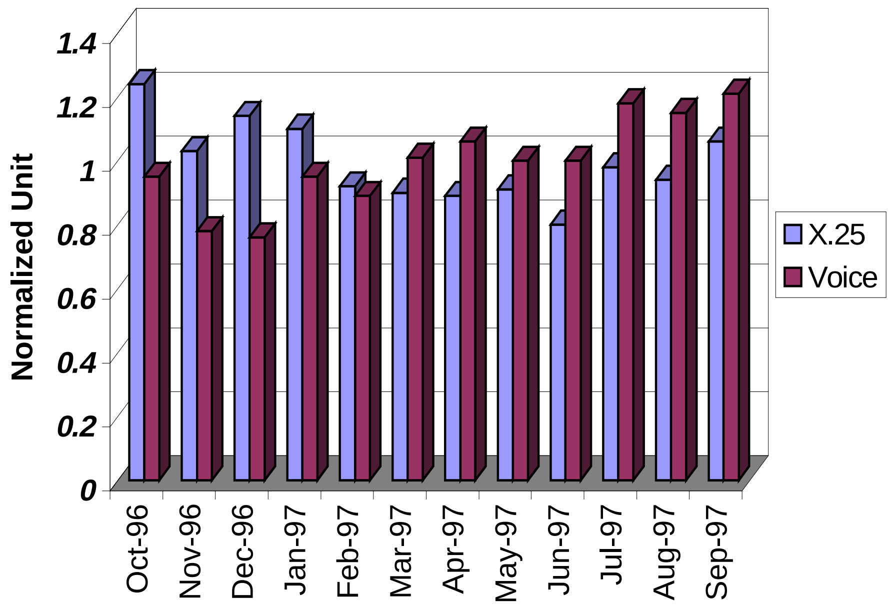

Figure 13 FY1997 Monthly Traffic Variation

3.4 Network Performance

Network performance, defined as the total delay of transmitted information (**T_d**), is the sum of three measurable network parameters:

($T_d = Q_d + T_t + P_d$)

where: Q_d is a queuing delay
T_t is the transmission time
P_d is the propagation delay

As described in Methodology Section 2.4, all three parameters contributing to the total delay can be measured with the NetMaker® XA. Because of the amount of time required to obtain a meaningful minimum set of traffic data, the Application Level Traffic study of the USDA Data Networks (Task V of the overall IEN Development plan) is not scheduled to be completed before the middle of March 1998. Therefore, the Network Performance analysis of the USDA networks is addressed in details at that time. The first part of the Application Level Traffic Study addresses the location of data probes. *Telecommunications Enterprise Network Design, Applications Level Traffic Study: Task V – Sniffer Placement Plan., November 25, 1997. Network Engineering Division*

3.5 Network Costs

A Network Cost Metric defines a specific set of parameters used to compare the effectiveness of alternative network designs. The Network Cost Metric measures the primary costs needed to implement and maintain a network. By definition, the Network Cost Metric is the sum of the monthly recurring charge for telecommunications services, the monthly recurring charge for equipment maintenance, and the amortized capital equipment cost. For the Baseline Study, the system life of the routers is assumed to be 36 months. Although these costs are presented separately for ease of understanding, they are considered one metric used to succinctly describe the state of the USDA Data Networks in monetary terms. There are other costs associated with implementing and maintaining a network, but they are much more difficult to quantify and are described in Section 3.5.4.

The Network Cost Metric represents the available information captured during the Network Baseline Study. The Network Cost Metric does not represent actual billed cost because not all router MIB values are correct and accurate tariffs are not known. As network design alternatives are proposed, the Network Cost Metric of the new design is compared to the value derived in the Baseline Study. Once design alternatives are thoroughly developed, a system life is assigned, thus permitting a direct dollar/unit comparison.

3.5.1 Monthly Recurring Service Charges

The monthly recurring charge for each Network design is based on the pricing of network links by NetMaker XA® Accountant module. The following factors affect the accurate pricing of the network links:

1. Correct service links must be identified as to DTS or Frame Relay.
2. Nodes must be accurately placed using their associated NPANXX.
3. Correct links sizes must be identified.
4. Correct tariff must be used.

Current analysis confirms that NetMaker XA® correctly identifies item 1, the type of service link from the MIB table. Items 2 and 3 require consistent population of router MIB fields. Using the correct tariff, item 4, requires review until NetMaker XA® produces an acceptable tariff. All of the four items affecting price require continual review to insure conformity with Baseline Network Costs.
The NetMaker XA® Accountant module sets tariff priorities to price WAN links in the network model. Since most node connecting links use FTS2000 services in the Baseline Model, the FTS2000 tariff was set to the highest priority. The generic tariff represents intra-LATA carrier prices. To allow pricing of links that do not use FTS2000, the generic tariff is set at a lower priority. Other inter-exchange carrier tariffs are not assigned a priority.

Newly discovered routers and routers with name changes since the October discovery are known to be incorrectly placed by the NetMaker XA® placement algorithm. The placement of these nodes has been accomplished by correcting the router NPANXX. Corrected NPANXXs are used in the Network Baseline Study.

Unless explicitly identified in a captured router MIB variable, NetMaker XA® calculates the PVCs to be 50% of the identified WAN access size for Frame Relay service. The WAN accesses were not modified during the Baseline Analysis, so the PVCs remain unchanged. Thus the total cost of PVCs remained constant for the Network Cost. This value is $10,319. NetMaker XA® has priced WAN links at $1,794,904 as the monthly recurring cost for services in the captured network. Table 5 presents the initial pricing of the Network Baseline.

The Baseline monthly recurring charge has been revised for two other reasons. Ten DTS WAN links had incorrectly identified link sizes of 1,544,000K, 1,666,666K, 56,179K, and 64,000K in the MIB value. Because of this obvious misidentification, these ten links have been incorrectly priced at $463,736. The price of these links have been reduced appropriately to better reflect the probable circuit links sizes. The NetMaker XA® initial monthly recurring charge reflects these changes.

	Service Type		
Size Class	DTS	FR	Size Total
0-64K	83,346	109798	193145
65-128K	12,348	57146	69494
129-256K	35742	27615	63357
257-384K		6680	6680
385-512K	7201	2924	10125
513-768K	6082	47162	53244
769-1024K	15790	1336	17126
1025-1536K	23992	8016	32008
T1	964211	375196	1339407
E1	0		0
Access Total	$1,148,712	$635,873	$1,784,586
PVCs			10319
Grand Total			**$1,794,905**

Table 5 Monthly Recurring Charge for Telecommunications Services

Analysis indicated that Frame Relay tariffs inappropriately priced access for both the origination and termination nodes. To mitigate this inappropriate pricing, the trunk charge for each Frame Relay has been reduced by 50%. The combination of these two refinement steps produces the cost figures shown in Table 6.

	Service Type		
Size Class	DTS	FR	Grand Total
0-64K	26,120	54,899	81,019
65-128K	12,348	28,573	40,921

129-256K	23,141	13,808	36,949
257-384K		3,340	3,340
385-512K	7,201	1,462	8,663
513-768K	6,082	23,581	29,663
769-1024K	15,790	668	16,458
1025-1536K	23,992	4,008	28,000
T1	570,303	187,598	757,901
E1	0		0
Access Total	**$684,976**	**$317,937**	**$1,002,913**
PVCs			**$10,319**
Grand Total			**$1,013,232**

Table 6 Revised Monthly Recurring Charge for Telecommunications Services

3.5.2 Monthly Recurring Cost for Equipment Maintenance

Equipment maintenance cost is based on the industry average of ten percent of the equipment cost per year. The equipment cost calculation is described in section 3.5.3. This annual cost is divided by twelve to calculate a monthly recurring cost. Table 7 shows the details of the calculation.

Router Type	Number	Annual Maintenance Cost per Router	Total Monthly Cost
3Com	3	150	38
CGS	1	150	13
Cisco 2500	512	400	17,067
Cisco 3000	65	750	4,063
Cisco 4000	162	1,200	16,200
Cisco 7000	37	6,000	18,500
Cisco Generic	36	400	1,200
IGS	7	150	88
Other	47	200	783
Welfleet	5	400	167
Total	**875**		**$57,117**

Table 7 Equipment Maintenance Costs

3.5.3 Amortized Equipment Cost

Equipment cost is the average cost of each type of router identified in the Baseline Model. The total number of routers by router type is used to calculate the one time investment for equipment (Table 8). The monthly cost reflects a 36 month amortization. Each design alternative shows how the number of routers and router types change and can be compared to the Baseline Network Cost Metric. The average cost for each router type is based on vendor price tables for the combination of components and chassis typical to a USDA platform.

Router Type	Number	Capital Cost per Router	Total Cost
3Com	3	1,500	4,500
CGS	1	1,500	1,500
Cisco 2500	512	4,000	2,048,000
Cisco 3000	65	7,500	487,500
Cisco 4000	162	12,000	1,944,000
Cisco 7000	37	60,000	2,220,000
Cisco Generic	36	4,000	144,000
IGS	7	1,500	10,500
Other	47	2,000	94,000
Welfleet	5	4,000	20,000
Total	**875**		**$6,854,000**
Amortized Monthly Cost			**$190,389**

Table 8 Capital Equipment Costs

3.5.4 Other Costs

The Network Cost Metric does not include some other known network costs. The technical staffing cost needed to maintain network routers is not quantifiable at this time but will be captured in the future as part of overall network management costs. Another cost factor not included in the Network Cost Metric is the productivity of Agency staff attributable to Data Networks. To quantify the productivity cost, the cost of staff associated with a mission application running over the network must be identified. This cost may be obtainable in the future.

3.5.5 Network Cost Metric

The Network Cost Metric is calculated as the sum of Monthly Equipment Maintenance costs, Monthly Service costs, and the 36 month Amortized Capital Equipment costs. Figure 14 graphically presents the component percentages of the Network Cost Metric.

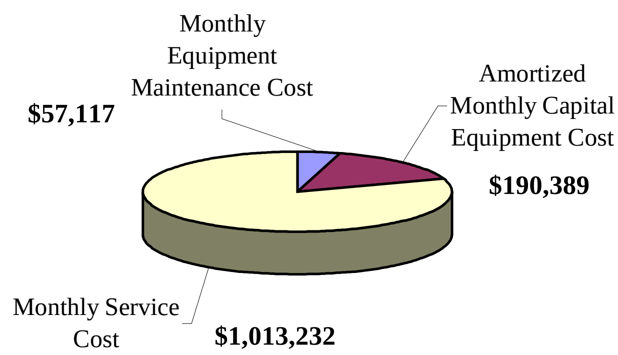

Figure 14 Network Cost Metric

3.6 Network Survivability

Survivability of a network corresponds to its ability to support the network traffic when one or more nodes or links fail. The NetMaker XA® tool has the capability to simulate failures of the USDA Data Networks model. The 'Analyzer' module of the tool shows how survivable the network is under failure conditions by automatically and systematically failing groups of objects within the physical model of the networks. Failure of the following network elements, individually and collectively, can be simulated:

- Router
- WAN Link
- LAN
- LAN Link
- Frame Relay POP
- Frame Relay Link
- LATA
- Facility
- City

All survivability reports generated by the NetMaker XA® tool are based on the effect of a failure on the demands (instance of traffic) being mapped onto the networks physical topology. Survivability reports identify worst case failure conditions in a network. In general, the failures that result in the largest percentage of failed demands are the worst case failures.

There are four types of reports available from the NetMaker XA® tool as the result of survivability analysis:

- Survivability Demand Summary Report - Demand Summary reports indicate the number of demands which failed for each failure analysis run.
- Survivability Demand Network Survivability Index (NSI) Report - The Demand NSI report provides individual NSI values for all active demands defined for the network. The Demand NSI indicates the viability of any one demand being

fully supported under the collective failure conditions being simulated. The Demand NSI provides an indication of how well aggregate demand is supported across all failures simulated.

- Survivability Network NSI Report - Network NSI reports present computed statistics regarding the average, worst and best case scenarios of network support under multiple load conditions. The Network NSI indicates the robustness of the network on a scale of 0% to 100%. To compute Network NSI, demands are weighted by their arrival rate (bits/sec).
- Survivability Analysis Log - The 'Analyzer' log presents bandwidth simulation statistics for each failure simulation. It displays the number of demands and percentage bandwidth that failed as well as the number of demands that were simulated.

As described for Performance Analysis, survivability analysis requires Application Level Traffic Data. Application Level Traffic demands reflect the end-to-end traffic (e.g. LAN-to-LAN)). Based on the Initial Enterprise Network Design Plan, the Application Level Traffic Study (Task V) is not available before mid-March 1998. The survivability analysis of the current USDA Networks is performed at that time.

3.7 USDA Data Network Topologies

Topologies of the current USDA Data Networks evolved from individual Agency requirements based on connectivity needs and available budgets. Some agencies have built their network to imitate their organizational structure. Associated with those networks, there is a variety of network topologies, each having various degrees of connectivity and vulnerabilities.

This section of the document addresses the USDA Data Network topologies in general terms; such a node type and overall network design. The details of individual Agency's network design are not addressed here. The analysis is based on the USDA Networks Discovery executed on October 29th, 1997 which does not contain all the information required for a detailed analysis of the current networks. It must also be mentioned that the dial-backup links, currently in place to be activated when a primary link fails, are not included in the current USDA Networks physical model.

In general, the USDA Data Network topologies are hybrid configurations such as ring, tree or hierarchical based structures, and star and branch designs. Some samples of logical network configurations have been extracted from the NetMaker XA® Discovery files and are provided here to illustrate the various network designs being used in the USDA Data Networks.

3.7.1 Network Nodes

Common to each topology are three categories of nodes being used in the networks. They are classified as:

- ‘Feeder’ Node - Feeder nodes serve as traffic sources such as access points for LANs. A feeder node may have a WAN link (DTS or Frame Relay PVC) to a node higher in the hierarchy such as a concentrator node or backbone node, if a backbone exists.
- ‘Concentrator’ Node - Concentrator nodes may perform as feeder nodes or serve as an access point for multiple feeders to connect to the backbone. There may be several concentrator levels in the hierarchy. In some instances, where there is no backbone, a concentrator node terminates the hierarchy.
- ‘Backbone’ Node - The backbone node is the highest node in the network hierarchy. Links between backbone nodes are for high speed, long distance traffic. Not all USDA Networks have a backbone configuration.

In most USDA network configurations, the inter-nodal connections consist of DTS and Frame Relay connections.

3.7.2 USDA Network Designs

As previously mentioned, the USDA Data Network topologies are hybrid configurations consisting of various ring, tree or hierarchical, and star designs.

3.7.2.1 Tree configurations

The classic ‘tree’ configuration is commonly used in USDA networks. It is more specifically used at the edge of the network.

Multi-level Hierarchical Tree - Figure 15 shows the hierarchical structure of an access area tree with multiple concentration levels. The feeder nodes connected to a set of first level concentrators, themselves connected to secondary concentrators, in turn connected to a single network’s backbone node (backbone in partial view at the bottom of the figure). This type of configuration provides only a single route between each traffic source and the backbone. Consequently, the routing is deterministic, providing no alternate paths in case of failure of concentrators and associated links. There are known instances of this type of configuration where USDA Agencies implemented on demand dial-backup links to by-pass failed network elements.

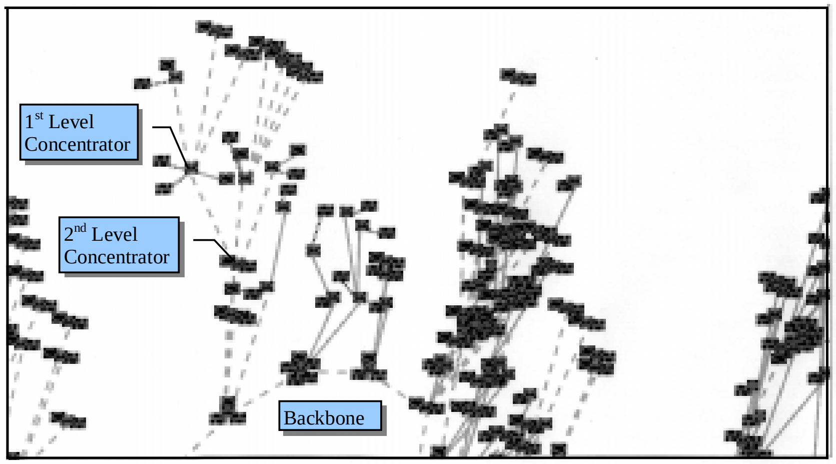

Figure 15 Multi-level Hierarchical Tree Configuration

Single-level Hierarchical Tree - Figure 16 shows tree configurations with no concentration level. All feeder nodes are directly connected to the backbone node. This type of configuration is typical when there is a limited number of feeders within the tree to be connected to the backbone. This design minimizes the propagation delay between feeder nodes and backbone. In this configuration also, there are instances of dial-backup being used between feeder nodes and their associated backbone access for survivability.

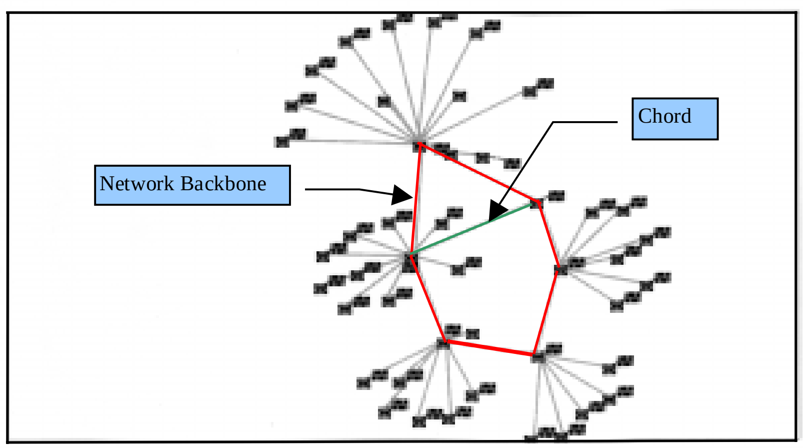

Figure 16 Single-level Hierarchical Tree Configuration

Tree Survivability - There are instances, within the USDA Networks, where alternate paths have been implemented (other than dial-backup) within the network tree configuration to address the problem of single route between traffic source and the backbone associated with the classic tree configuration. As shown in Figure

17, concentrator nodes are interconnected to provide multiple paths between the feeder nodes and the backbone (not shown). This configuration increases the tree branches survivability in the event concentrators or associated link fail.

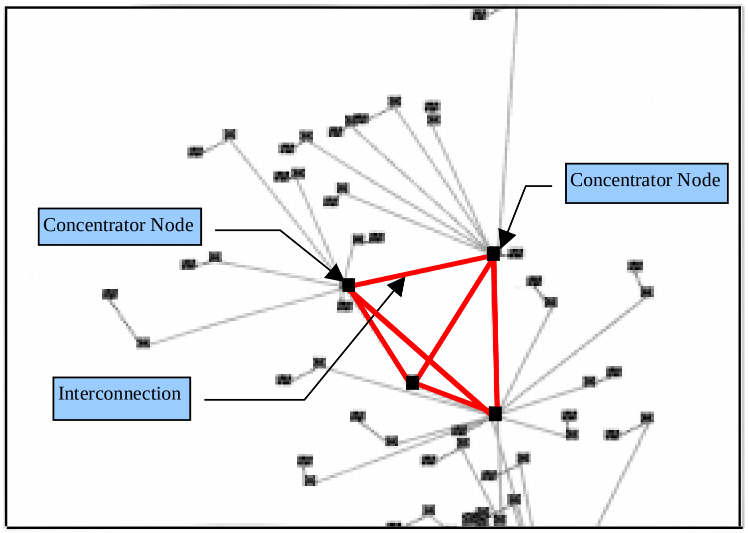

Figure 17 Concentrator Nodes Connected by Chords

3.7.2.2 Network Core Configurations

Several network 'core' configurations are used in the USDA Networks. These include 'star' configuration, 'Simple ring' backbone, 'semi-chordal' ring backbone and combinations of two or more of these configurations.

Star configuration - The use of the single or multiple star configurations is widely used by the USDA Agencies. An example of the single star topology is the Washington, D. C. headquarters Frame Relay PVC to each field office. This type of configuration provides no direct connectivity between field offices. All data transfer must pass through the headquarters' hub node.

There are also instances where multiple (2 and 3) large stars are interconnected via a backbone ring. While the connectivity characteristics between branch of the star remains unchanged, connectivity between star hubs is provided by the backbone, and in the event of hub or backbone link failure, only part of the network is affected.

Simple Ring Backbone Configuration
The simple ring network design is used by some USDA Agencies to create a backbone. Figure 18 shows the logical view of a seven node

simple ring backbone. To each of the backbone nodes are attached a hierarchical tree structure. For this configuration, all logical points of the backbone "see" the same logical network and require the fewest number of links. In addition, it provides good survivability for a single point of failure. However, the simple ring backbone is vulnerable to two or more points of failure as any subset of sequential nodes around the ring can be disconnected from the rest of the backbone. In addition, this configuration is prone to congestion for high volume traffic.

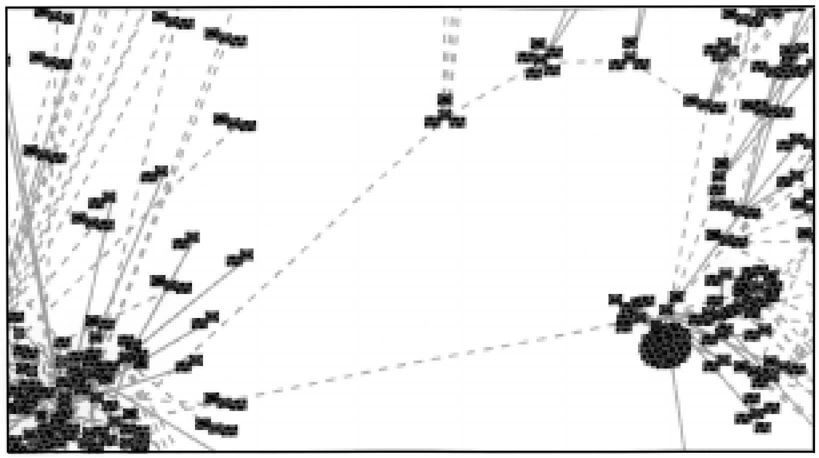

Figure 18 Simple Ring Backbone Configuration

Chordal Ring Backbone Configuration
Some USDA networks use a chordal ring backbone. A chordal ring backbone is a ring in which one or more chord links are placed across the network. Figure 16 above shows the logical view of a chordal ring backbone (single chord) and its associated one level hierarchical trees connected to the backbone nodes. This configuration, while increasing the number of links in the backbone, partially solves the problem of congestion and vulnerability found in the simple ring backbone design. The placement and number of the chordal links within the ring is very much dependent on the data volume and survivability requirements.

4.0 Conclusions

4.1 Network Equipment

Hardware identified as "in use" on USDA Networks includes routers from several manufacturers; but an overwhelming majority (93%) are Cisco models. The predominate Cisco routers are Model 2500 (62%) and Model 4000 (20%). No information is available regarding the service support level of these router models.

Inter-network Operating System (IOS) software in use with USDA routers is classified in four support levels. End-of-Life releases no longer supported by Cisco, represent 48% of the USDA routers. Software no longer supported by engineering changes (End-of-Engineering) represents 29%. Software no longer sold but supported by Cisco (End-of-Sales) is 8%. Of all router software in use with USDA routers, only 13% has full support.

The description of equipment used on USDA Data Networks indicates a general lack of standards and coordination. The fact that most hardware is a single brand is probably fortuitous and reflects Cisco's predominate market share. Common hardware used throughout the USDA Networks simplifies configuration control and service support during transition to the IEN. The predominance of unsupported software makes the network vulnerable to unnecessary failure by problems resolved in newer software versions.

4.2 Network Services

Network Services represent the various types of connectivity required by Agencies to accomplish their mission programs. The Network Baseline Study identified several network service connections in use by USDA Data Networks: LANs, Internet access, USDA Data Center access, Web Servers, Dial-up needs, FTS Mail, access to other Government Agencies, state and local institution, and commercial organizations.

The predominate network connection services used by USDA Networks is the LAN. The LAN connects workstations and other entities that share a geographic locale and often common work activities. The Ethernet LAN is the primary type (98%) found. Several FDDI LANs are used in the Washington, D. C., metropolitan area. Both Ethernet and FDDI LANs are reliable technologies and should facilitate IEN development.

The other network services are in use to varying degrees by all USDA Agencies. The Agency specific implementation of these services does not take advantage of volume cost savings and service standardization. These services represent a good area for improvement by the Enterprise Network development process.

4.3 Network Utilization

Network utilization is defined as the amount of data traffic on network interconnections. Utilization data is measured electronically and expressed as the percent of use relative to circuit capacity. For 693 connections identified, an "average" and "high" day utilization has been calculated.

Utilization results indicate very inefficient use of USDA Network circuits. "Average" Day utilization indicates that 79% of the USDA Network circuits are used at 10% or less of their capacity. Even on a "high" day, 64% of the USDA Network circuits are used at less than 10% capacity. This data does not reflect measurement at a particularly low traffic period. USDA Network utilization results suggest network design that is inefficient and, therefore, very costly.

4.4 Network Performance

Network performance is expressed in terms of delay experienced during data transmission. The network performance metric, total delay, is the sum of queuing delay, transmission delay, and propagation delay. Since delay attributes can only be measured with application level traffic, network performance measurement will be derived following the Network Level Traffic Study (March 13, 1998).

4.5 Network Costs

An important factor for IEN design comparison is the definition of a Network Cost Metric. The Network Cost Metric is the sum of recurring monthly service costs, recurring monthly equipment maintenance costs, and capital equipment costs. The Network Cost Metric components are measured electronically with the NetMaker XA® System.

Network cost information for the USDA Network Baseline is the paradigm to which IEN designs are compared. From the best information available, recurring monthly service costs for the existing USDA Networks is approximately $1.01M. Recurring monthly equipment maintenance is $57,000 and amortized monthly capital equipment cost is $190,400. The resulting monthly Network Cost Metric for the USDA Baseline is $1.26M.

4.6 Network Survivability

Network Survivability reflects all elements of a network and the ability of these elements to support network traffic in failure mode. Survivability is measured electronically when failure modes are simulated by the NetMaker XA® System. Network survivability can be expressed with any of several metrics calculated by the NetMaker XA®. Since application level traffic information is required to accurately express these metrics, network survivability will not be measured until the Application Level Traffic Study is complete (March 13, 1998).

4.7 Network Topologies

The topologies of current USDA Data Networks are a result of individual Agency requirements for connectivity and available budget. The resulting network topologies are often implemented for particular Agency's needs but do not always represent Department-wide effectiveness and efficiency. Many Agency network configurations converge on central locations; a construction that is susceptible to overloading and large scale failure consequences. Converging designs limit geographical consolidation and therefore make it more difficult to share network resources.

The shortcomings of converging networks is illustrated in the example shown in Figures 19 and 20. This example shows how a planned network consolidation might look if existing networks were used with no re-design of the WAN portions of the network. In Great Falls, MT, there is a FS office along with the Great Falls Service Center encompassing FSA, NRCS, and RD field offices. Logically and from a cost analysis, it makes sense for the Service Center to share the FS WAN network to communicate with the rest of the USDA network. However, potential

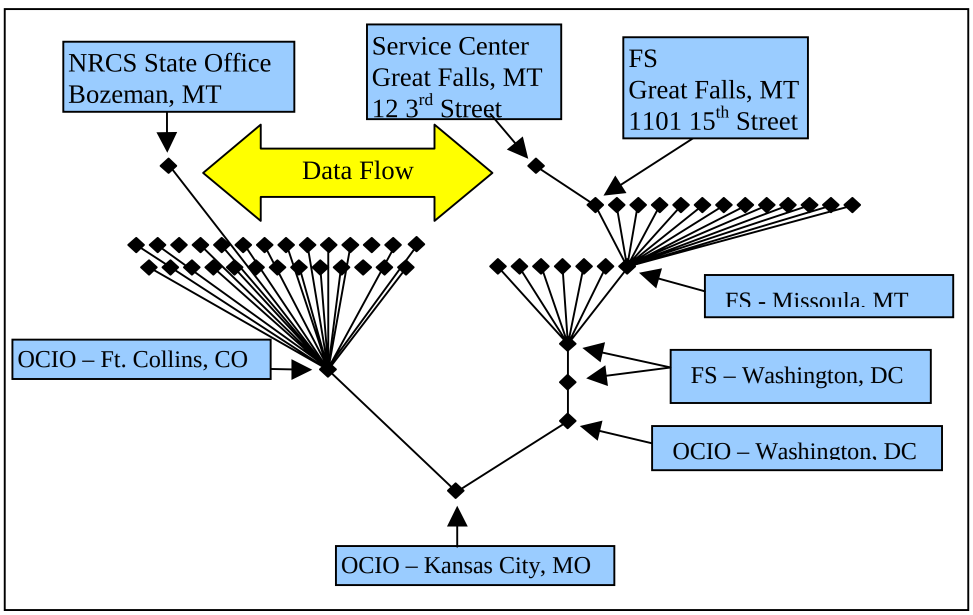

Figure 19 Logical View of Consolidation Example

problems develop when considering the situation where the Great Falls Service Center needs to communicate with the NRCS state office in Bozeman. Because the FS network was not originally designed to accommodate other USDA traffic, the path the NRCS traffic must follow is susceptible to overloading, performance, and reliability problems. This problem is magnified as additional consolidation efforts are implemented on the Agency networks.

Although the example presented is specific to an FS and Service Center optimization site, it is representative of the type of problem being created by attempts to share networking resources in the USDA. Building-by-building or city-by-city consolidations alone, without re-engineering the higher level network connections, cause problems in network capacity, performance, and reliability. Application of the GNAP for the high level or WAN networks, taking into account the LAN to LAN traffic flows, will alleviate these problems.

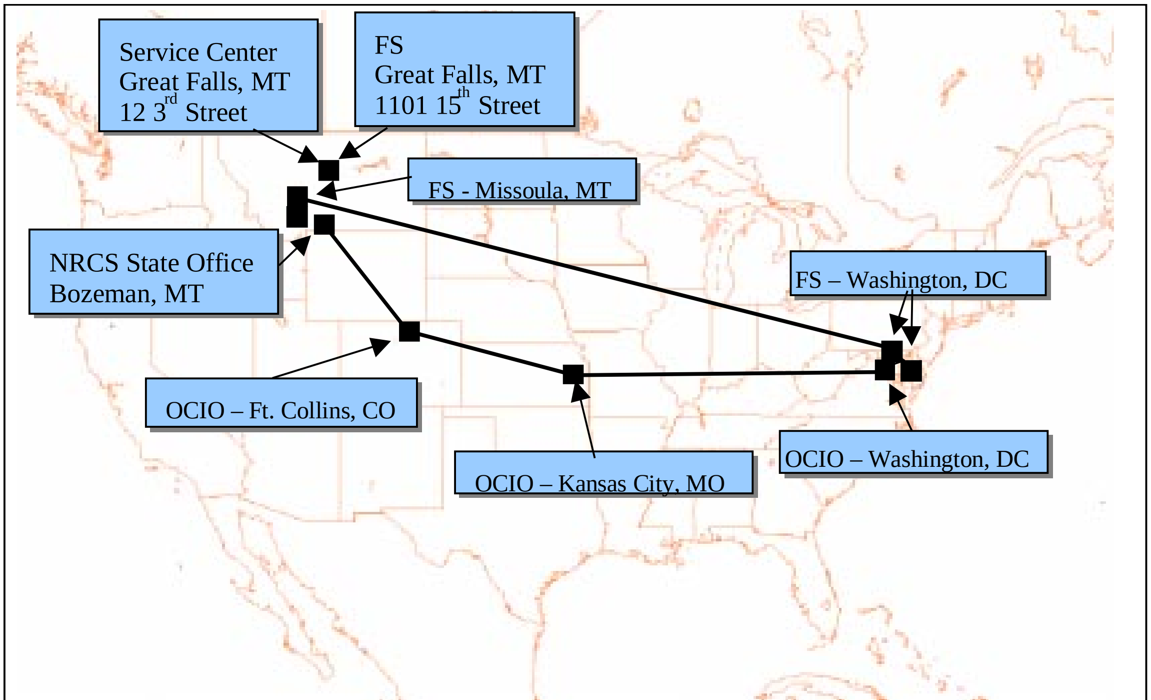

Figure 20 Geographical View of Consolidation Example

Virtually all basic types of network designs are being used by USDA Data Networks. In most cases individual Agency network configurations are a hybrid of several basic designs. Network topology is an important characteristic when assessing network survivability and cost. No information has been tabulated to quantify network types.

6.0 Glossary

ANSI	American National Standards Institute **–** Organization made of voluntary participant organizations (e.g. large computer companies) crating standards for the industry.
CIR	Committed Information Rate - The information transfer rate which the network is committed to transfer under normal conditions. The CIR is negotiated at subscription time.
CSMA/CD	Carrier Sense Multiple Access/Collision Detect – A set of rules determining how network devices respond when two devices attempt to use a data channel simultaneously.
DTS	Dedicated Transmission Service – the FTS2000 service offering non-switched (leased line) point-to-point transmission.
FDDI	Fiber Distributed Data Interface – A set of ANSI protocols for sending digital data over fiber optic cable.
FR	Frame Relay - Frame Relay is a multiplexing protocol designed to operate over transmission facilities that are virtually error free. The Frame Relay technology utilizes logical link multiplexing to allow multiple logical connections to exist across a single access line. The basic protocol data unit of Frame Relay is a frame.
IEEE802	A set of standards, related to LANs, developed by the Institute of Electrical and Electronic Engineers**.**
LEC	Local Exchange Carrier – A carrier who provides transport service between points within a single LATA, or between an end user and an Inter-Exchange Carrier for inter-LATA transmission.
LAN	Local Area Network – a group of computers typically connected by no more than 1,000 feet of cable, which inter-operate and allow people to share resources.
NPANXX	Numbering Plan Area (NPA -NXX) - The NPANXX consist of the 3 digit area code follow by the 3 digit exchange number (i.e. 970-282). This convention is used to determine distance sensitive telecommunications service costs (e.g. Private Line service).
NSI	Network Survivability Indices - The Network NSI indicates the viability of the network on a scale of 0 to 100. The individual NSI

values indicate the viability of any one demand being fully supported under the joint failure conditions, which are simulated.

OSI Open System Interconnection – An International Standards Organization standard for worldwide communications that defines a framework for implementing protocols in seven layers – the Seven Layers OSI Model.

POP Point of Presence – A location where a subscriber can access to telecommunications services from a service provider (i.e. Local exchange Carrier).

PVC Permanent Virtual Circuit - A Frame Relay virtual circuit that has a logical channel permanently assigned to it at each data terminal equipment (e.g.: router). A call establishment protocol is not required.

SNMP Simple Network Management Protocol – A set of protocols for managing complex networks.

TCP/IP Transmission control Protocol/Internet protocol – A suite of communication protocols used to connect hosts on the network.

WAN Wide Area Network – A computer network that spans a relatively large geographical area. Computers connected to a WAN are often connected through public networks.